(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 862 156 B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent: **20.04.2005 Bulletin 2005/16**

(21) Application number: **97940411.8**

(22) Date of filing: **18.09.1997**

(51) Int Cl.7: **H01L 51/40**, H01L 27/00, H05B 33/12, G02F 1/1333, G09F 9/30, G09F 9/00

(86) International application number: **PCT/JP1997/003297**

(87) International publication number: **WO 1998/012689 (26.03.1998 Gazette 1998/12)**

(54) METHOD OF PRODUCTION OF A MATRIX TYPE DISPLAY DEVICE

VERFAHREN ZUR HERSTELLUNG EINER MATRIXANZEIGEVORRICHTUNG

PROCEDE DE FABRICATION D'UN ECRAN MATRICIEL

(84) Designated Contracting States:
DE GB NL

(30) Priority: **19.09.1996 JP 24808796**

(43) Date of publication of application:
02.09.1998 Bulletin 1998/36

(60) Divisional application:
03077361.8 / 1 365 276
03077362.6 / 1 365 443
03077468.1 / 1 367 431

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Description

Technical Field

[0001] The present invention relates to a manufacturing method of a matrix type display device, and particularly to the manufacturing of a matrix type display device having a structure in which luminescent material is selectively arranged at predetermined positions on a display substrate, the material being liquid at least during coating, wherein the material can accurately be arranged at the predetermined positions.

Background Art

[0002] Matrix type display devices such as an LCD (Liquid Crystal Display), an EL (Electroluminescence) display device, and the like are frequently used as various display devices that are light weight, thin, and have high image quality and high definition. A matrix type display device comprises matrix-formed bus lines, an optical material (luminescent material or light modulation material), and if required, other components.

[0003] In a monochromatic matrix type display device, wiring and electrodes must be arranged in a matrix on the display substrate, but the optical material can be uniformly coated over the entire surface of the display substrate.

[0004] In contrast, for example, when a so-called matrix type color display device is realized by using an EL display device of the type that emits light by itself, it is necessary to arrange three pixel electrodes corresponding to the primary colors RGB of light for each pixel, and coat the optical material corresponding to any one of the primary colors RGB for each pixel electrode. Namely, the optical material must be selectively arranged at the predetermined positions.

[0005] There is thus demand for developing a method of patterning the optical material. Suitable examples of effective patterning methods include etching and coating.

[0006] The etching process is carried out as follows.

[0007] First, a layer of an optical material is formed over the entire surface of the display substrate. Then a resist layer is formed on the optical material layer, exposed to light through a mask and then patterned. Then the optical material layer is patterned by etching in correspondence with the resist pattern.

[0008] However, in this case, a large number of steps are required, and each of the materials and apparatus used is expensive, thereby increasing the cost. Also a large number of steps are required, and each of the steps is complicated, thereby deteriorating throughput. Further, depending upon chemical properties, some optical materials have low resistance to resist and an etchant, and thus these steps are impossible.

[0009] On the other hand, the coating process is carried out as follows.

[0010] First, an optical material is dissolved in a solvent to form a solution, and the thus-formed solution of the optical material is selectively coated at the predetermined positions on the display substrate by an ink jet method or the like. Then, if required, the optical material is solidified by heating, irradiation of light, or the like. In this case, a small number of steps are required, and each of the materials and apparatus used is inexpensive, thereby decreasing the cost. Also, a small number of steps are required, and each of the steps is simple, thereby improving throughput. Further, these steps are possible regardless of the chemical properties of the optical material used as long as a solution of the optical material can be formed.

[0011] The coating patterning method is thought to be easily carried out. However, as a result of experiment, the inventors found that in coating the optical material by the ink jet method, the optical material must be diluted at least several tens of times with a solvent, and thus the solution obtained has high fluidity, thereby causing difficulties in holding the solution at the coating positions until it is completely solidified after coating.

[0012] In other words, patterning precision deteriorates due to the fluidity of the solution of the optical material. For example, the optical material coated in a pixel flows to the adjacent pixels to deteriorate the optical properties of the pixels. Also variations occur in the coating areas in the respective pixels, thereby causing variations in the coating thickness and thus the optical properties of the optical material.

[0013] Although this problem significantly occurs with an optical material for EL display devices or the like, which is liquid during coating and then solidified, the problem also occurs in cases in which a liquid crystal that is liquid both during and after coating is selectively coated on the display substrate.

[0014] The present invention has been achieved in consideration of the unsolved problem of the prior art, and an object of the invention is to provide a matrix type display a manufacturing method in which electrolumunescent material can securely be arranged at predetermined positions while maintaining characteristics such as low cost, high throughput, a high degree of freedom of the material, etc.

[0015] JP 06281917A, JP 07132288A, JP 03192334A, US 5399390 and US 5274481 all disclose the use of liquid crystal material dispersed with polymer material of different colours to form a display device. Different colour polymer dispersed liquid crystal materials are partitioned from one another and disposed between two substrates.

[0016] JP 6308312A discloses the formation of colour filters, having a uniform film surface, for use in a display device.

[0017] DE 19603451A discloses a method of forming an electroluminescent display device, in which strips of electroluminescent material are formed.

[0018] According to the present invention, there is

provided a method of manufacturing a matrix type display device including a first electrode supported by a display substrate, a second electrode arranged over the first electrode, an electroluminescent light emitting element held between the first electrode and the second electrode, a scanning line, a signal line, and a switching element for controlling the states of the first electrode, the method comprising the steps of:

forming a difference in height at a peripheral region around the first electrode so as to make the height of the peripheral region around the first electrode higher than that of the first electrode with respect to the display substrate; and
applying a liquid solution, comprising an optical material held in a solvent, to a predetermined position corresponding to the first electrode; and
evaporating the solvent so as to form the electroluminescent light emitting element.

Brief Description of the Drawings

[0019]

Fig. 1 is a diagram of a circuit showing a portion of a display device in accordance with a first embodiment of the present invention.
Fig. 2 is an enlarged plan view showing the plane structure of a pixel region.
Figs. 3 to 5 are sectional views showing the flow of a manufacturing process in accordance with the first embodiment.
Fig. 6 is a sectional view showing a modified embodiment of the first embodiment.
Fig. 7 is a plan view and sectional view showing a second embodiment.
Fig. 8 is a sectional view showing a portion of a manufacturing process in accordance with a third embodiment, not forming part of the present invention.
Fig. 9 is a sectional view showing a portion of a manufacturing process in accordance with a fourth embodiment.
Fig. 10 is a sectional view showing a portion of a manufacturing process in accordance with a fifth embodiment.

Best Mode for Carrying Out the Invention

[0020] Preferred embodiments of the present invention will be described below on the basis of the drawings.

(1) First embodiment

[0021] Figs. 1 to 5 are drawings illustrating a first embodiment of the present invention. In this embodiment, a matrix type display device and a manufacturing method thereof of the present invention are applied to an active matrix type EL display device. Specifically, these drawings show an embodiment in which a luminescent material as an optical material is coated, and scanning lines, signal lines and common current supply lines serve as wiring.

[0022] Fig. 1 is a drawing of a circuit showing a portion of a display device 1 in this embodiment. The display device 1 comprises wiring including a plurality of scanning lines 131, a plurality of signal lines 132 extending in the direction crossing the scanning lines 131, and a plurality of common current supply lines 133 extending parallel to the signal lines 132; and a pixel region 1A provided for each of the intersections of the scanning lines 131 and the signal lines 132.

[0023] For the signal lines 132, a data side driving circuit 3 comprising a shift register, a level shifter, a video line, and an analog switch is provided. For the scanning lines 131, a scanning side driving circuit 4 comprising a shift register and a level shifter is provided. Provided in each pixel region 1A are: a switching thin film transistor 142 in which a scanning signal is supplied to a gate electrode through a scanning line 131, a storage capacitor cap for holding an image signal supplied from a signal line 132 through the switching thin film transistor 142, a current thin film transistor 143 in which the image signal held by the storage capacitor cap is supplied to a gate electrode, a pixel electrode 141 to which a driving current flows from a common current supply line 133 at the time of electrical connection to the common current supply line 133 through the current thin film transistor 143, and a light emitting element 140 held between the pixel electrode 141 and a reflection electrode 154.

[0024] In this configuration, when the switching thin film transistor 142 is turned on by driving the scanning lines 131, the potential of the signal lines 132 is held by the storage capacitor cap, and the on-off state of the current thin film transistor 143 is determined in accordance with the state of the storage capacitor cap. Then a current flows to the pixel electrode 141 from the common current supply lines 133 through the channel of the current thin film transistor 143, and a current flows to the reflection electrode 154 through the light emitting element 140, whereby the light emitting element 140 emits light in accordance with the amount of the current flowing therethrough.

[0025] Each of the pixel regions 1A has a planar structure in which the pixel electrode 141 having a rectangular planar shape is arranged so that the four sides thereof are surrounded by a signal line 132, a common current supply line 133, a scanning line 131 and a scanning line for another pixel electrode, as shown in Fig. 2 which is an enlarged plan view with the reflection electrode and the light emitting element removed.

[0026] Figs. 3 to 5 are sectional views successively showing the steps for manufacturing the pixel region 1A, and correspond to a section taken along line A-A in Fig. 2. The process for manufacturing the pixel region 1A is described with reference to Figs. 3 to 5.

[0027] First, as shown in Fig. 3(a), on a transparent

display substrate 121 is formed a base protective film (not shown) comprising a silicon oxide film having a thickness of about 2000 to 5000 angstroms by a plasma CVD method using TEOS (tetraethoxysilane) and oxygen gas as raw material gases according to demand. Next, the temperature of the display substrate 121 is set to about 350°C, and on the surface of the base protective film is formed a semiconductor film 200 comprising an amorphous silicon film having a thickness of about 300 to 700 angstroms (1μm = 10^4 Å) by the plasma CVD method. The semiconductor film 200 comprising an amorphous silicon film is then subjected to the crystallization step by laser annealing or solid phase growth to crystallize the semiconductor film 200 to a polysilicon film. In laser annealing, for example, an excimer laser line beam having a long dimension of 400 mm and an output strength of, for example, 200 mJ/cm^2 is used. The line beam is scanned so that a portion thereof corresponding to 90% of the laser strength peak in the direction of the short dimension is applied to each of the regions.

[0028] Next, as shown in Fig. 3(b), the semiconductor film 200 is patterned to form an island-like semiconductor film 210, and on the surface of the semiconductor film 210 is formed a gate insulating film 220, comprising a silicon oxide film or nitride film having a thickness of about 600 to 1500 angstroms, by the plasma CVD method using TEOS (tetraethoxysilane) and oxygen gas as raw material gases. Although the semi-conductor film 210 is used for the channel region and source/drain regions of the current thin film transistor 143, another semiconductor film is also formed for forming the channel region and source/drain regions of the switching thin film transistor 142 in another sectional view. Namely, in the manufacturing process shown in Figs. 3 to 5, two types of transistors 142 and 143 are simultaneously formed, but both transistors are formed according to the same procedure. Therefore, with respect to the transistors, only the current thin film transistor 143 is described below, and description of the switching thin film transistor 142 is omitted.

[0029] Next, as shown in Fig. 3(c), a conductive film comprising a metallic film of aluminum, tantalum, molybdenum, titanium, tungsten, or the like is formed by a sputtering method, and then patterned to form a gate electrode 143A.

[0030] In this state, a high concentration of phosphorus ions is implanted to form source and drain regions 143a and 143b in the silicon thin film 210 in self-alignment to the gate electrode 143. A portion into which the impurity is not introduced serves as a channel region 143c.

[0031] Next, as shown in Fig. 3(d), an interlevel insulation film 230 is formed, contact holes 232 and 234 are formed, and then trunk electrodes 236 and 238 are buried in the contact holes 232 and 234, respectively.

[0032] Next, as shown in Fig. 3(e), on the interlevel insulation film 230 are formed a signal line 132, a common current supply line 133 and a scanning line (not shown in Fig. 3). Each of the signal lines 132, the common current supply lines 133 and the scanning lines is formed sufficiently thick regardless of the required thickness as wiring. Specifically, each of the lines is formed to a thickness of about 1 to 2 μm. The trunk electrode 238 and each of the lines may be formed in the same step. In this case, the trunk electrode 238 is formed of an ITO film which will be described below.

[0033] Then an interlevel insulation film 240 is formed to cover the upper surfaces of the lines, a contact hole 242 is formed at a position corresponding to the trunk electrode 236, and an ITO film is formed to fill the contact hole 242 therewith, followed by patterning of the ITO film to form a pixel electrode 141 electrically connected to the source and drain region 143a at the predetermined position surrounded by the signal line 132, the common current supply line 133 and the scanning line.

[0034] In Fig. 3(e), the portion between the signal line 132 and the common current supply line 133 corresponds to the predetermined position where the optical material is arranged. A difference in height 111 is formed between the predetermined position and the periphery thereof by the signal line 132 and the common current supply line 133. Specifically, the difference in height 111 is formed in a concave shape in which the predetermined position is lower than the periphery thereof.

[0035] Next, as shown in Fig. 4 (a), a liquid (a solution in a solvent) optical material (precursor) 114A for forming a hole injection layer corresponding to a lower layer of the light emitting element 140 is discharged by an ink jet head method with the upper side of the display substrate 121 turned upward to selectively coat the optical material on the region (the predetermined position; surrounded by the difference in height 111. Since detailed contents of the ink jet method are not included in the gist of the present invention, the contents are omitted (For such a method, refer to Japanese Unexamined Patent Publication Nos. 56-13184 and 2-167751, for example).

[0036] Materials for forming the hole injection layer include polyphenylenevinylene obtained from polytetrahydrothiophenylphenylene as a polymer precursor, 1,1-bis-(4-N,N-ditolylaminophenyl)cyclohexane, tris (8-hydroxyquinolynol) aluminum, and the like.

[0037] At this time, although the liquid precursor 114A has high fluidity and tends to horizontally spread, the difference in height 111 is formed to surround the coating position, thereby preventing the liquid precursor 114A from spreading to the outside of the predetermined position beyond the difference in height 111 as long as the amount of the liquid precursor 114A coated in a single application is not excessively increased.

[0038] Next, as shown in Fig. 4(b), the solvent of the liquid precursor 114A is evaporated by heating or light irradiation to form a thin, solid hole injection layer 140a on the pixel electrode 141. Depending upon the concentration of the liquid precursor 114A, only a thin hole injection layer 140a is formed. Therefore, where a thicker

hole injection layer 140a is required, the steps shown in Figs. 4 (a) and (b) are repeatedly executed a necessary number of times to form the hole injection layer 140A having a sufficient thickness, as shown in Fig. 4(c).

[0039] Next, as shown in Fig. 5(a), a liquid (a solution in a solvent) of an optical material (organic fluorescent material) 114B for forming an organic semiconductor film corresponding to an upper layer of the light emitting element 140 is discharged by the ink jet head method with the upper surface of the display substrate 121 turned upward to selectively coat the optical material on the region (the predetermined position) surrounded by the difference in height 111.

[0040] Organic fluorescent materials include cyanopolyphenylenevinylene, polyphenylenevinylene, polyalkylphenylene, 2,3,6,7-tetrahydro-11-oxo-1H,5H,11H (1) benzopyrano[6,7,8-ij]-quinolizine-10-carboxylic acid, 1,1-bis-(4-N,N-ditolylaminophenyl)cyclohexane, 2-13',4'-dihydroxyphenyl)-3,5,7-trihydroxy-1-benzopyrylium perchlorate, tris(8-hydroxyquinolynol)aluminum, 2,3,6,7-tetrahydro-9-methyl-11-oxo-1H,5H,11H (1) benzopyrano[6,7,8-ij]-quinolizine, aromatic diamine derivatives (TDP), oxydiazole dimers (OXD), oxydiazole derivatives (PBD), distyrylarylene derivatives (DSA), quinolynol metal complexes, beryllium-benzoquinolynol derivatives (Bebq), triphenylamine derivatives (MTDATA), distyryl derivatives, pyrazoline dimers, rubrene, quinacridone, triazole derivatives, polyphenylene, polyalkylfluorene, polyalkylthiophene, azomethine zinc complexes, porphyrin zinc complexes, benzoxazole zinc complexes, phenanthroineeuropiem complexes, and the like.

[0041] At this time, although the liquid organic fluorescent material 114B has high fluidity and tends to horizontally spread, the difference in height 111 is formed to surround the coating position, thereby preventing the liquid organic fluorescent material 114B from spreading to the outside of the predetermined position beyond the difference in height 111 as long as the amount of the liquid organic fluorescent material 114B coated in a single application is not excessively increased.

[0042] Next, as shown in Fig. 5(b), the solvent of the liquid organic fluorescent material 114B is evaporated by heating or light irradiation to form a solid organic semiconductor thin film 140b on the hole injection layer 140A. Depending upon the concentration of the liquid organic fluorescent material 114B, only a thin organic semiconductor film 140b is formed. Therefore, where a thicker organic semiconductor layer 14Cb is required, the steps shown in Figs. 5(a) and (b) are repeatedly executed a necessary number of times to form the organic semiconductor film 140B having a sufficient thickness, as shown in Fig. 5(c).

[0043] The hole injection layer 140A and the organic semiconductor film 140B constitute the light emitting element 140. Finally, as shown in Fig. 5(d), the reflection electrode 154 is formed over the entire surface of the display substrate 121 or in stripes.

[0044] In this embodiment, lines such as the signal line 132, the common current supply line 133, and the like are formed to surround the processing position where the light emitting element 140 is arranged, and are formed to have a thickness larger than the normal thickness to form the difference in height 111, and the liquid precursor 114A and the liquid organic fluorescent material 1143 are selectively coated. Therefore, this embodiment has the advantage that the patterning precision of the light emitting element 140 is high.

[0045] Although the formation of the difference in height 111 causes the reflection electrode 154 to have a surface with relatively large unevenness, the possibility of producing a trouble such as disconnection or the like is significantly decreased by increasing the thickness of the reflection electrode 154 to some extent.

[0046] In addition, since the difference in height 111 is formed by using the lines such as the signal line 132, the common current supply line 133, and the like, a new step is not added, and the manufacturing process is not significantly complicated.

[0047] In order to securely prevent the liquid precursor 114A and the liquid organic fluorescent material 114B from flowing out from the inside of the difference in height 111, the following relation is preferably established between the coating thickness d_a of the liquid precursor 114A and the liquid organic fluorescent material 114B and the height d_r of the difference in height 111.

$$d_a < d_r \qquad (1)$$

[0048] However, when the liquid organic fluorescent material 114B is coated, the hole injection layer 140 A has already been formed, and thus the height d_r of the difference in height 111 must be considered as a value obtained by subtracting the thickness of the hole injection layer 140A from the initial thickness.

[0049] Also, equation (1) is satisfied, and the following relation is established between the driving voltage V_d applied to the organic semiconductor film 140B, the total thickness d_b of the liquid organic fluorescent material 114B, the concentration r of the liquid organic fluorescent material 114B, and the minimum electric field strength E_t (threshold electric field strength) at which a change in optical properties of the organic semiconductor film 140B occurs.

$$V_d/(d_b \cdot r) > E_t \qquad (2)$$

In this case, the relation between the coating thickness and the driving voltage is defined, and it is ensured that the organic semiconductor film 1403 exhibits an electrooptical effect.

[0050] On the other hand, in order to ensure the flatness of the difference in height 111 and the light emitting

element 140 and uniformity in changes in the optical properties of the organic semiconductor film 140B, and prevent short circuit, the following relation may be established between the thickness d_f of the light emitting element 140 at the time of completion and the height d_r of the difference in height 111:

$$d_f = d_r \quad (3)$$

[0051] In addition, if equation (3) is satisfied, and the following equation (4) is satisfied, the relation between the thickness of the light emitting element 140 at the time of completion and the driving voltage is defined, and it is ensured that the organic fluorescent material exhibits an electro-optical effect.

$$V_d/d_f > E_t \quad (4)$$

[0052] However, in this case, the thickness d_f is the thickness of the organic semiconductor film 140B at the time of completion, not the thickness of the entire light emitting element 140.

[0053] The optical material which forms the upper layer of the light emitting layer 140 is not limited to the organic fluorescent material 114B, and an inorganic fluorescent material may be used.

[0054] Each of the transistors 142 and 143 as switching elements is preferably made of polycrystalline silicon formed by a low temperature process at 600°C or less, thereby achieving low cost by using a glass substrate, and high performance due to high mobility. The switching elements may be made of amorphous silicon or polycrystalline silicon formed by a high temperature process at 600°C or higher.

[0055] Besides the switching thin film transistor 142 and the current thin film transistor 143, another transistor may be provided, or a system of driving by only one transistor may be used.

[0056] The difference in height 111 may be formed by using the first bus lines in a passive matrix display device, the scanning lines 131 in an active matrix display device, or the light shielding layer.

[0057] In the light emitting element 140, the hole injection layer 140A may be omitted, though the efficiency of light emission (rate of hole injection) slightly deteriorates. Alternatively, an electron injection layer is formed between the organic semiconductor film 140B and the reflection electrode 154 in place of the hole injection layer 140A, or both the hole injection layer and the electron injection layer may be formed.

[0058] Although, in this embodiment, the entire light emitting element 140 is selectively arranged in consideration of color display, for example, in a monochrome display device 1, the organic semiconductor film 140B may be uniformly formed over the entire surface of the display substrate 121, as shown in Fig. 6. However, even in this case, the hole injection layer 140A must be selectively arranged at each of the predetermined positions in order to prevent crosswalk, and thus it is significantly effective to coat the optical material by using the difference in height 111.

(2) Second embodiment

[0059] Fig. 7 is a drawing showing a second embodiment of the present invention in which a matrix type display device and a manufacturing method thereof in accordance with the present invention are applied to a passive matrix type display device using an EL display device.

[0060] Fig. 7 (a) is a plan view showing the arrangement of a plurality of first bus lines 300 and a plurality of second bus lines 310 arranged perpendicularly to the first bus lines 300, and Fig. 7(b) is a sectional view taken along line B-B in Fig. 7(a). The same components as the first embodiment are denoted by the same reference numerals, and description thereof is omitted. Since details of the manufacturing process are also the same as the first embodiment, the process is not shown in the drawings nor described.

[0061] Namely, in this embodiment, an insulation film 320 of SiO_2, for example, is arranged to surround the predetermined position where the light emitting element 140 is disposed, to form the difference in height 111 between the predetermined position and the periphery thereof.

[0062] Like the first embodiment, this structure is capable of preventing the liquid precursor 114A and the liquid organic fluorescent material 114B from flowing out to the periphery during selective coating, and has the advantage of achieving high-precision patterning.

(3) Third embodiment (not forming part of the present invention).

[0063] Fig. 8 is a drawing showing a third embodiment not forming part of the present invention in which, like in the first embodiment, a matrix type display device and a manufacturing method thereof in accordance with the present invention are applied to an active matrix type EL display device. Specifically, the difference in height 111 is formed by using the pixel electrode 141, thereby permitting high-precision patterning. The same components as the above embodiments are denoted by the same reference numerals. Fig. 8 is a sectional view showing an intermediate step of the manufacturing process, and the steps before and after this step are not shown nor described because they are substantially the same as the first embodiment.

[0064] Namely, in this embodiment, the pixel electrode 141 is formed to have a thickness larger than a normal thickness to form the difference in height 111 between the pixel electrode 141 and the periphery thereof.

In other words, in this embodiment, the difference in height is formed in a convex shape in which the pixel electrode 141 later coated with the optical material is higher than the periphery thereof.

[0065] Like in the first embodiment, in order to form the hole injection layer corresponding to the lower layer of the light emitting element 140, the liquid (a solution in a solvent) optical material (precursor) 114A is discharged to coat the optical material on the upper surface of the pixel electrode 141.

[0066] However, unlike in the first embodiment, the liquid precursor 114A is coated on the display substrate while the display substrate is reversed, i.e., in the state where the upper surface of the pixel electrode 141 that is coated with the precursor 114A is turned downward.

[0067] As a result, the liquid precursor 114A stays on the upper surface of the pixel electrode due to gravity and surface tension, and does not spread to the periphery thereof. Therefore, the liquid precursor 114A can be solidified by heating or light irradiation to form the same thin hole injection layer as shown in Fig. 4(b), and this step is repeated to form the hole injection layer. The organic semiconductor film can also be formed by the same method.

[0068] In this way, in this embodiment, the liquid optical material is coated by using the difference in height 111 formed in a convex shape, thereby improving patterning precision of the light emitting element.

[0069] The amount of the liquid optical material staying on the upper surface of the pixel electrode 141 may be adjusted by using inertial force such as centrifugal force or the like.

(4) Fourth embodiment

[0070] Fig. 9 is a drawing showing a fourth embodiment of the present invention in which like in the first embodiment, a matrix type display device and a manufacturing method thereof in accordance with the present invention are applied to an active matrix type EL display device. The same components as the above embodiments are denoted by the same reference numerals. Fig. 9 is a sectional view showing an intermediate step of the manufacturing process, and the steps before and after this step are not shown nor described because they are substantially the same as the first embodiment.

[0071] Namely, in this embodiment, first the reflection electrode 154 is formed on the display substrate 121, and then the insulation film 320 is formed on the reflection electrode 154 to surround the predetermined position where the light emitting element 140 is arranged later, and to form the difference in height 111 in a concave shape in which the predetermined position is lower than the periphery thereof.

[0072] Like in the first embodiment, the liquid optical material is then selectively coated in the region surrounded by the difference in height 111 by the ink jet method to form the light emitting element 140.

[0073] On the other hand, scanning lines 131, signal lines 132, pixel electrodes 141, switching thin film transistors 142, current thin film transistcrs 143 and an insulation film 240 are formed on a peeling substrate 122 through a peeling layer 152.

[0074] Finally, the structure peeled off from the peeling layer 122 on the peeling substrate 122 is transferred onto the display substrate 121.

[0075] In this embodiment, the liquid optical material is coated by using the difference in height 111, thereby permitting patterning with high precision.

[0076] Further, in this embodiment, it is possible to decrease damage to the base material such as the light emitting element 140 in subsequent steps, or damage to the scanning lines 131, the signal lines 132, the pixel electrodes 141, the switching thin film transistors 142, the current thin film transistors 143 or the insulation film 240, due to coating of the optical material.

[0077] Although, in this embodiment, an active matrix type display device is described, a passive matrix type display device may be used.

(5) Fifth embodiment

[0078] Fig. 10 is a drawing showing a fifth embodiment of the present invention in which like in the first embodiment, a matrix type display device and a manufacturing method thereof in accordance with the present invention are applied to an active matrix type EL display device. The same components as the above embodiments are denoted by the same reference numerals. Fig. 10 is a sectional view showing an intermediate step of the manufacturing process, and the steps before and after this step are not shown nor described because they are substantially the same as the first embodiment.

[0079] Namely, in this embodiment, the difference in height 111 is formed in a concave shape by using the interlevel insulation film 240 to obtain the same operation and effect as the first embodiment.

[0080] Also, since the difference in height 111 is formed by using the interlevel insulation film 240, a new step is not added, and thus the manufacturing process is not significantly complicated.

[0081] The difference in height 111 may be formed by forming a material on the peeling substrate through the peeling layer and then transferring the structure peeled off from the peeling layer on the peeling substrate onto the display substrate.

[0082] Although, in each of the above embodiments, an organic or inorganic EL material is used as the optical material, the optical material is not limited to these materials, and may be a liquid crystal.

Industrial Applicability

[0083] As described above, in the present invention, since a liquid optical material is coated by using a difference in height, there is the effect of improving the pat-

terning precision of the optical material.

Claims

1. A method of manufacturing a matrix type display device (1) including a first electrode (141) supported by a display substrate (121), a second electrode (154) arranged over the first electrode, an electroluminescent light emitting element (140) held between the first electrode and the second electrode, a scanning line, a signal line, and a switching element for controlling the states of the first electrode, the method comprising the steps of:

   forming a difference in height (111) at a peripheral region (131, 132) around the first electrode so as to make the height of the peripheral region around the first electrode higher than that of the first electrode with respect to the display substrate; and
   applying a liquid solution, comprising an optical material (114A, 114B) held in a solvent, to a predetermined position corresponding to the first electrode; and
   evaporating the solvent so as to form the electroluminescent light emitting element.

2. A method according to claim 1, further comprising:

   forming wiring including the scanning line, the signal line and the switching element for controlling the states of the first electrode in accordance with a signal supplied through the wiring above a peeling substrate through a peeling layer; and
   transferring a structure including the wiring and the switching element from the peeling substrate onto the display substrate.

3. A method according to claim 1, wherein the difference in height is formed in a concave shape by using the scanning line and the signal line, in which the predetermined position is lower than the periphery thereof; and

   in the step of applying the liquid optical material, the liquid optical material is applied to the predetermined position with the surface of the display substrate that has the liquid optical material applied thereto being turned upward.

4. A method according to claim 1 or claim 3, further comprising the step of forming an interlevel insulation film;

   wherein the difference in height is formed in a concave shape by using the interlevel insulation film (240) above the scanning line, in which the predetermined position is lower than the periphery thereof; and

   in the step of applying the liquid optical material, the liquid optical material is applied to the predetermined position with the surface of the display substrate that has the liquid optical material applied thereto being turned upward.

5. A method according to claim 1, wherein the difference in height is formed on a peeling substrate through a peeling layer in the step of forming the difference in height, and then the structure peeled off from the peeling layer on the peeling substrate is transferred onto the display substrate.

6. A method according to any one of the preceding claims, wherein the height dr of the difference in height satisfies the following equation (1) :

$$da < dr \quad (1)$$

   wherein:

   da: thickness of a single application of the liquid optical material.

7. A method according to claim 6, wherein the following equation (2) is satisfied:

$$Vd/(db \bullet r) > Et \quad (2)$$

   wherein:

   Vd: driving voltage applied to the optical material;
   db: total thickness of the liquid optical material applied;
   r: concentration of the liquid optical material;
   Et: minimum electric field strength (threshold electric field strength) at which a change in optical properties of the liquid optical material occurs.

8. A method according to any one of claims 1 to 5, wherein the following equation (3) is satisfied:

$$df = dr \quad (3)$$

   wherein:

   df: thickness of the optical material at the time of completion;

9. A method according to claim 8, wherein the following equation (4) is satisfied:

$$Vd/df > Et \quad (4)$$

wherein:

Vd: driving voltage applied to the optical material;
Et: minimum electric field strength (threshold electric field strength) at which a change in optical properties of the liquid optical material occurs. .

10. A method according to any one of the preceding claims, wherein the optical material is an organic or inorganic fluorescent material,

11. A method according to any one of the preceding claims, wherein the switching elements comprise amorphous silicon, polycrystalline silicon formed by a high-temperature process at 600°C or higher, or polycrystalline silicon formed by a low-temperature process at 600°C or lower.

12. A method according to any one of the preceding claims wherein the liquid optical material is applied by an ink jet method.

Patentansprüche

1. Verfahren zur Herstellung einer Matrixanzeigevorrichtung (1) mit einer ersten Elektrode (141), die von einem Anzeigesubstrat (121) gehalten wird, einer zweiten Elektrode (154), die über der ersten Elektrode angeordnet ist, einem elektrolumineszenten, lichtemittierenden Element (140), das zwischen der ersten Elektrode und der zweiten Elektrode gehalten wird, einer Abtastleitung, einer Signalleitung und einem Schaltelement zum Steuern der Zustände der ersten Elektrode, wobei das Verfahren folgende Schritte umfasst:

   Bilden einer Höhendifferenz (111) an einem peripheren Bereich (131, 132) um die erste Elektrode, so dass die Höhe des peripheren Bereichs um die erste Elektrode höher als jene der ersten Elektrode in Bezug auf das Anzeigesubstrat wird; und

   Aufbringen einer flüssigen Lösung, die ein optisches Material (114A, 114B) in einem Lösemittel umfasst, auf eine vorbestimmte Position, die der ersten Elektrode entspricht; und

   Verdampfen des Lösemittels zur Bildung des elektrolumineszenten, lichtemittierenden Elements.

2. Verfahren nach Anspruch 1, des Weiteren umfassend:

   Bilden einer Verdrahtung einschließlich der Abtastleitung, der Signalleitung und des Schaltelements zum Steuern der Zustände der ersten Elektrode entsprechend einem Signal, das durch die Verdrahtung zugeleitet wird, über einem Ablösesubstrat durch eine Ablöseschicht; und
   Übertragen einer Struktur, die die Verdrahtung und das Schaltelement enthält, von dem Ablösesubstrat auf das Anzeigesubstrat.

3. Verfahren nach Anspruch 1, wobei die Höhendifferenz in einer konkaven Form unter Verwendung der Abtastleitung und der Signalleitung gebildet wird, wobei die vorbestimmte Position tiefer als deren Peripherie liegt; und
in dem Schritt zum Aufbringen des flüssigen optischen Materials das optische Material auf der vorbestimmten Position aufgebracht wird, wobei die Oberfläche des Anzeigesubstrats, auf die das flüssige optische Material aufgebracht wird, nach oben gedreht ist.

4. Verfahren nach Anspruch 1 oder Anspruch 3, des Weiteren umfassend den Schritt zum Bilden eines Zwischenlagen-Isolierfilms;
wobei die Höhendifferenz in einer konkaven Form unter Verwendung des Zwischenlagen-Isolierfilms (240) über der Abtastleitung gebildet wird, wobei die vorbestimmte Position tiefer als deren Peripherie liegt; und
in dem Schritt zum Aufbringen des flüssigen optischen Materials das optische Material auf der vorbestimmten Position aufgebracht wird, wobei die Oberfläche des Anzeigesubstrats, auf die das flüssige optische Material aufgebracht wird, nach oben gedreht ist.

5. Verfahren nach Anspruch 1, wobei die Höhendifferenz auf einem Ablösesubstrat durch eine Ablöseschicht in dem Schritt zur Bildung der Höhendifferenz gebildet wird, und dann die Struktur, die von der Ablöseschicht auf dem Ablösesubstrat abgelöst wird, auf das Anzeigesubstrat übertragen wird.

6. Verfahren nach einem der vorangehenden Ansprüche, wobei die Höhe dr der Höhendifferenz die folgende Gleichung (1) erfüllt:

$$da < dr \quad (1)$$

wobei:

   da: Dicke einer einzelnen Aufbringung des flüs-

sigen optischen Materials.

7. Verfahren nach Anspruch 6, wobei die folgende Gleichung (2) erfüllt ist:

$$Vd/(db \bullet r) > ET \quad (2)$$

wobei:

Vd: Antriebsspannung, die an das optische Material angelegt wird;
db: Gesamtdicke des aufgebrachten, flüssigen, optischen Materials;
r: Konzentration des flüssigen optischen Materials;
Et: Minimale elektrische Feldstärke (elektrische Schwellenfeldstärke), bei der eine Änderung in den optischen Eigenschaften des flüssigen optischen Materials eintritt.

8. Verfahren nach einem der Ansprüche 1 bis 5, wobei die folgende Gleichung (3) erfüllt ist:

$$df = dr \quad (3)$$

wobei:

df: Dicke des optischen Materials zum Zeitpunkt der Vollendung.

9. Verfahren nach Anspruch 8, wobei die folgende Gleichung (4) erfüllt ist:

$$Vd/df > Et \quad (4)$$

wobei:

Vd: Antriebsspannung, die an das optische Material angelegt wird;
Et: Minimale elektrische Feldstärke (elektrische Schwellenfeldstärke), bei der eine Änderung in den optischen Eigenschaften des flüssigen optischen Materials eintritt.

10. Verfahren nach einem der vorangehenden Ansprüche,
wobei das optische Material ein organisches oder anorganisches fluoreszierendes Material ist.

11. Verfahren nach einem der vorangehenden Ansprüche,
wobei die Schaltelemente Silizium, polykristallines Silizium, das durch einen Hochtemperaturprozess bei 600 °C oder mehr gebildet wird, oder polykristallines Silizium, das durch einen Niedertemperaturprozess bei 600 °C oder weniger gebildet wird, umfassen.

12. Verfahren nach einem der vorangehenden Ansprüche,
wobei das flüssige optische Material durch ein Tintenstrahlverfahren aufgebracht wird.

Revendications

1. Méthode de fabrication d'un dispositif d'affichage matriciel (1) comprenant une première électrode (141) supportée par un substrat d'affichage (121), une deuxième électrode (154) disposée au-dessus de la première électrode, un élément d'émission de la lumière électroluminescent (140) maintenu entre la première électrode et la deuxième électrode, une ligne de balayage, une ligne de transfert de signaux, et un élément de commutation pour commander les états de la première électrode, la méthode comprenant les étapes suivantes :

formation d'une différence de hauteur (111) au niveau d'une zone périphérique (131, 132) autour de la première électrode, de manière à ce que la hauteur de la zone périphérique autour de la première électrode soit supérieure à celle de la première électrode par rapport au substrat d'affichage ; et

application d'une solution liquide comprenant une matière optique (114A, 114B) contenue dans un solvant, en un emplacement prédéfini correspondant à la première électrode; et

soumission du solvant à évaporation afin de former l'élément d'émission de la lumière électroluminescent.

2. Méthode selon la revendication 1, consistant par ailleurs à:

former un câblage comprenant la ligne de balayage, la ligne de transfert de signaux, et l'élément de commutation afin de commander les états de la première électrode en fonction d'un signal fourni via le câblage, au-dessus d'un substrat d'exfoliation par
l'intermédiaire d'une couche d'exfoliation ; et
transfert d'une structure comprenant le câblage et l'élément de commutation depuis le substrat d'exfoliation jusque sur le substrat d'affichage.

3. Méthode selon la revendication 1, où la différence de hauteur est réalisée avec une forme concave en utilisant la ligne de balayage et la ligne de transfert de signaux, l'emplacement prédéfini étant plus bas

que sa périphérie; et
au cours de l'étape d'application de la matière optique liquide, la matière optique liquide étant appliquée sur l'emplacement prédéfini, la surface du substrat d'affichage sur laquelle la matière optique liquide est appliquée étant tournée vers le haut.

4. Méthode selon la revendication 1 ou la revendication 3, comprenant par ailleurs l'étape de formation d'une pellicule isolante de niveau intermédiaire ;
la différence de hauteur étant réalisée avec une forme concave en utilisant la pellicule isolante de niveau intermédiaire (240) au-dessus de la ligne de balayage, l'emplacement prédéfini étant plus bas que sa périphérie ; et
au cours de l'étape d'application de la matière optique liquide, la matière optique liquide étant appliquée sur l'emplacement prédéfini, la surface du substrat d'affichage sur laquelle la matière optique liquide est appliquée étant tournée vers le haut.

5. Méthode selon la revendication 1, où la différence de hauteur est réalisée sur un substrat d'exfoliation par l'intermédiaire d'une couche d'exfoliation au cours de l'étape de formation de la différence en hauteur, et la structure qui est enlevée par exfoliation de la couche d'exfoliation sur le substrat d'exfoliation étant ensuite transférée sur le substrat d'affichage.

6. Méthode selon l'une quelconque des revendications précédentes, où la hauteur dr correspondant à la différence de hauteur, satisfait à l'équation suivante (1) :

$$da < dr \tag{1}$$

où

da : épaisseur d'une seule application de la matière optique liquide.

7. Méthode selon la revendication 6, où l'équation suivante (2) est satisfaite :

$$Vd/(db \bullet r) > Et \tag{2}$$

où

Vd : tension d'entrée appliquée à la matière optique ;
db : épaisseur totale de la matière optique liquide appliquée ;
r : concentration de la matière optique liquide ;
Et : intensité minimale du champ électrique (intensité de seuil du champ électrique) à laquelle un changement des propriétés optiques de la matière optique liquide a lieu.

8. Méthode selon l'une quelconque des revendications 1 à 5, où l'équations suivante (3) est satisfaite :

$$df = dr \tag{3}$$

où

df : épaisseur de la matière optique au moment de l'achèvement.

9. Méthode selon la revendication 8, où l'équation suivante (4) est satisfaite :

$$Vd/df > Et \tag{4}$$

où

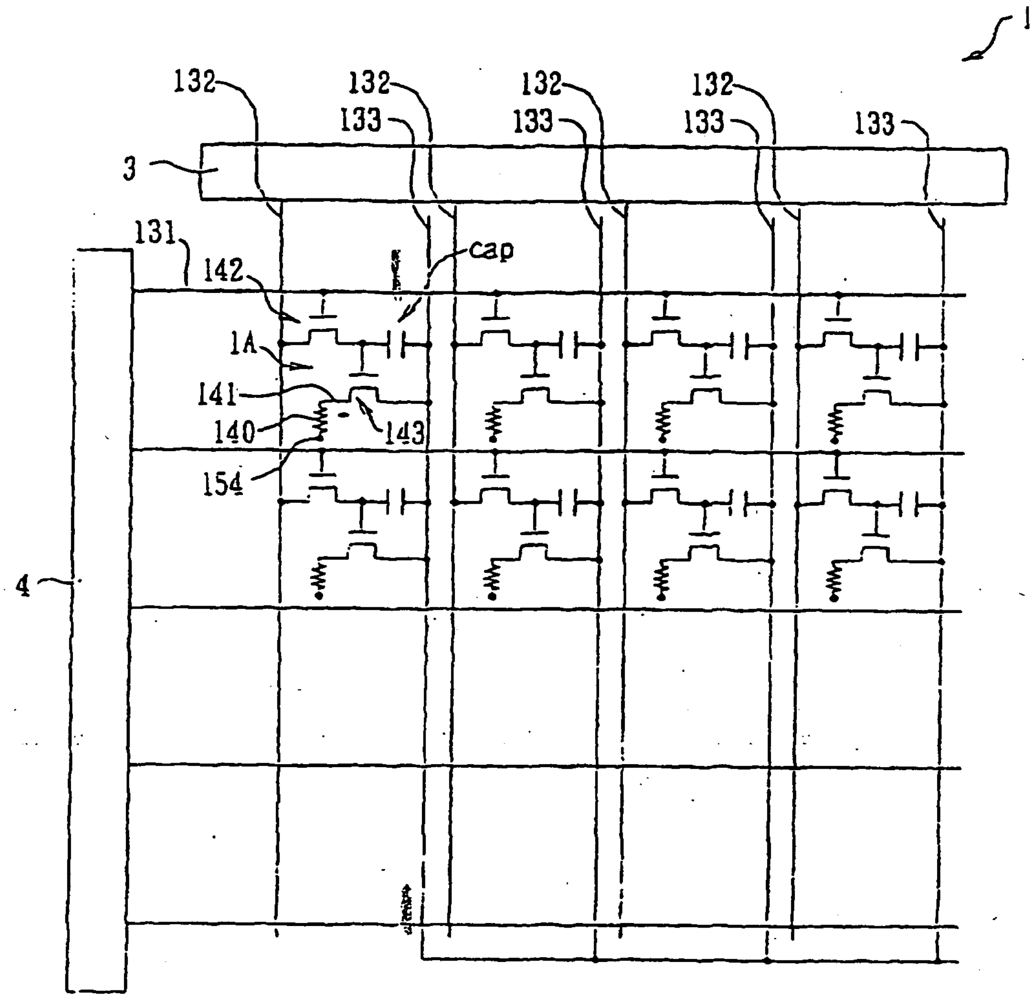
Vd : tension d'entrée appliquée à la matière optique ;
Et : intensité minimale du champ électrique (intensité de seuil du champ électrique) à laquelle un changement des propriétés optiques de la matière optique liquide a lieu.

10. Méthode selon l'une quelconque des revendications précédentes, où la matière optique est une matière fluorescente organique ou inorganique.

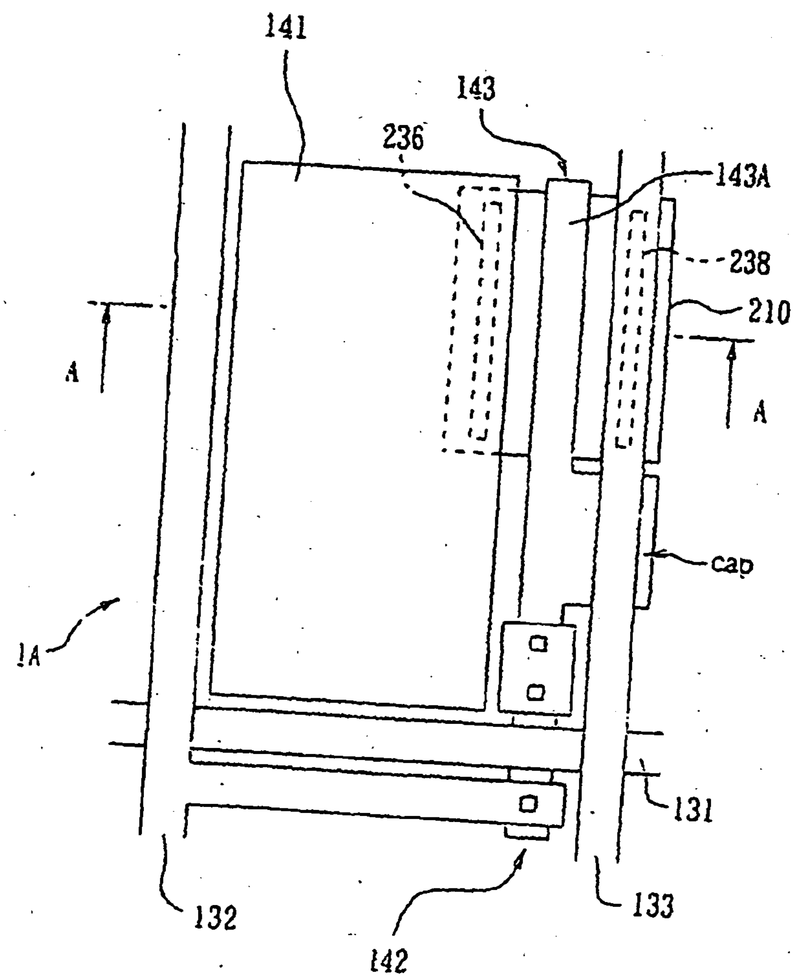
11. Méthode selon l'une quelconque des revendications précédentes, où les éléments de commutation comprennent du silicium amorphe, du silicium polycristallin formé grâce à un procédé à température élevée de 600 °C ou plus, ou du silicium polycristallin formé grâce à un procédé à basse température à 600 °C ou moins.

12. Méthode selon l'une quelconque des revendications précédentes, où la matière optique liquide est appliquée grâce à une méthode de jet d'encre.

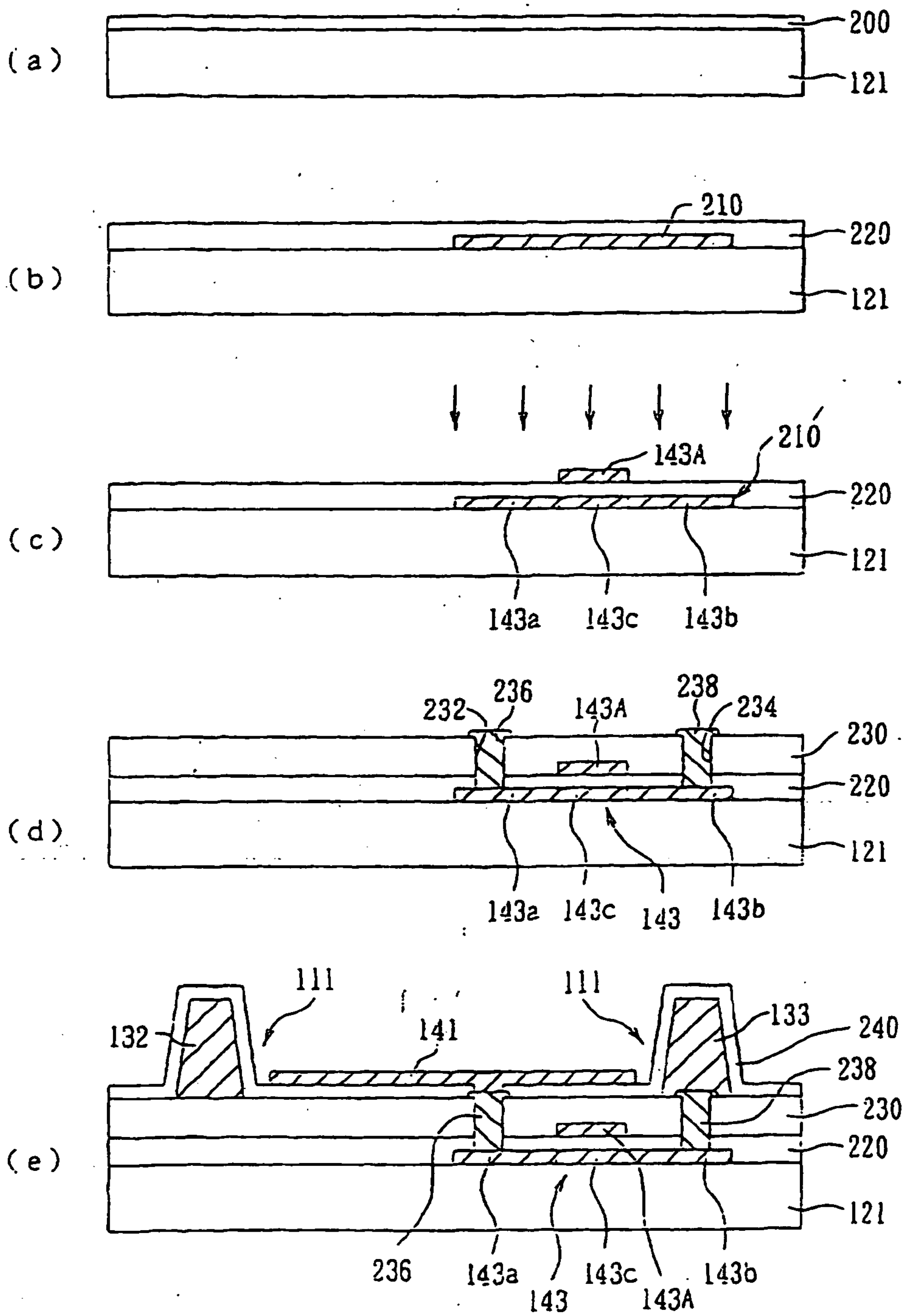
[FIG. 1]



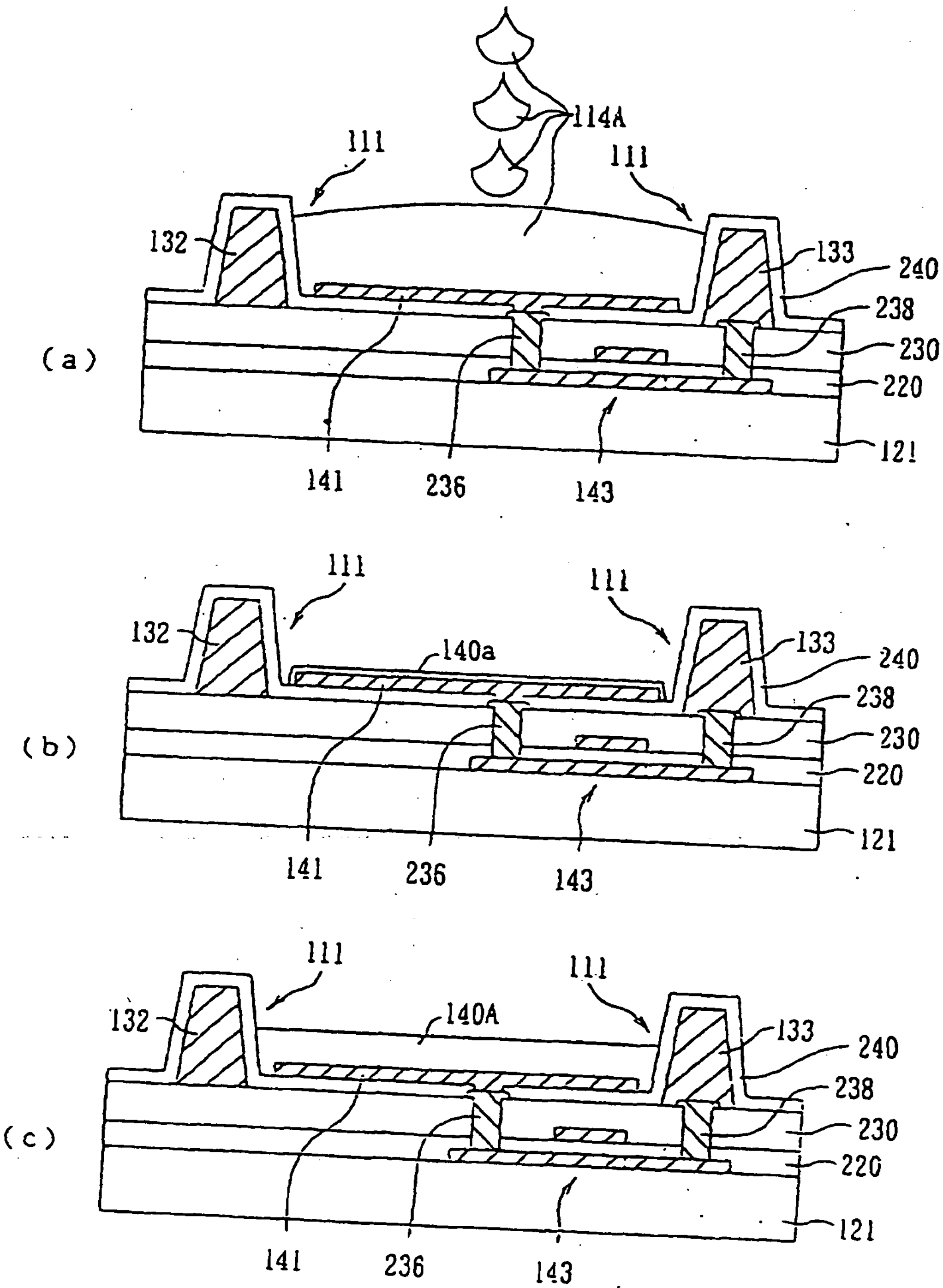
[FIG. 2]



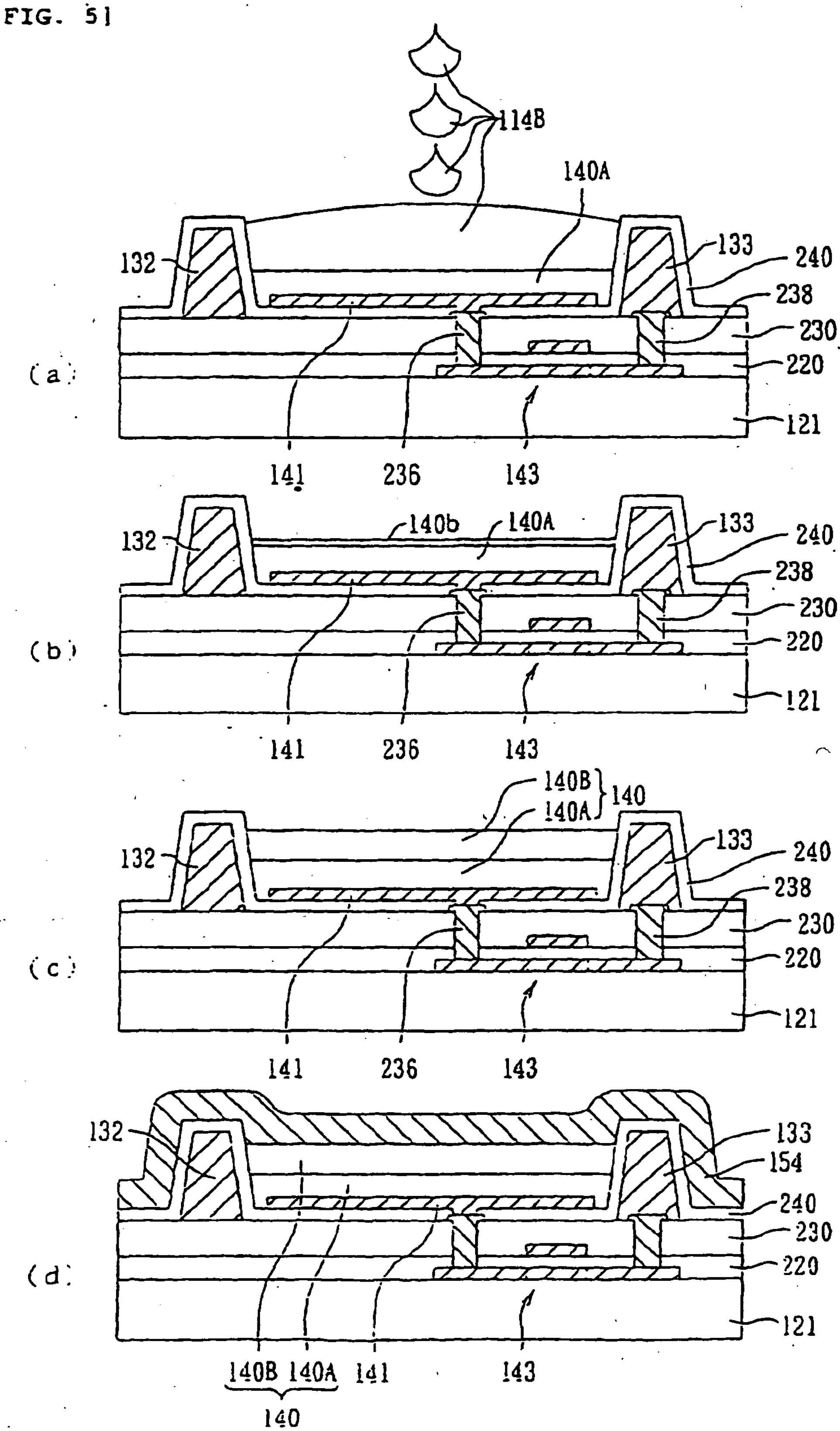
[FIG. 3]


(a)
200
121
(b)
210
220
121
(c)
210
143A
220
121
143a
143c
143b
(d)
232
236
143A
238
234
230
220
121
143a
143c
143
143b
(e)
111
141
111
132
133
240
238
230
220
121
236
143a
143
143c
143A
143b

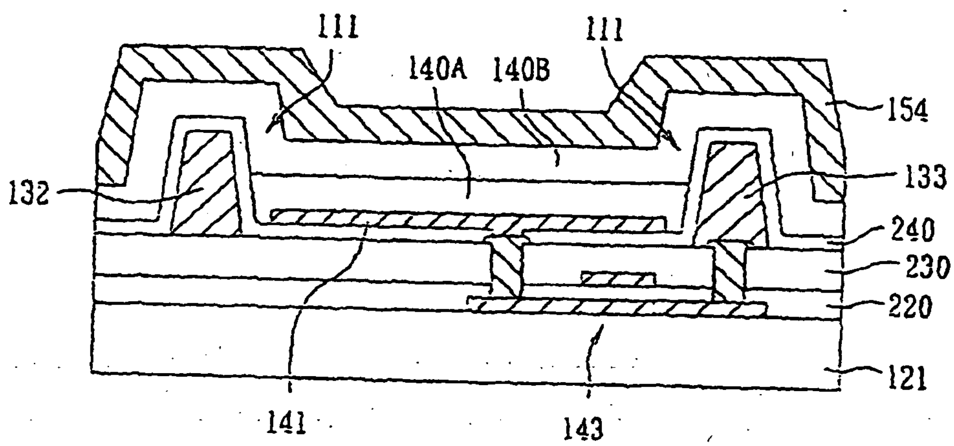
[FIG. 4]


(a)
114A
111
111
132
133
240
238
230
220
121
141
236
143
(b)
111
111
132
140a
133
240
238
230
220
121
141
236
143
(c)
111
111
132
140A
133
240
238
230
220
121
141
236
143

[FIG. 5]

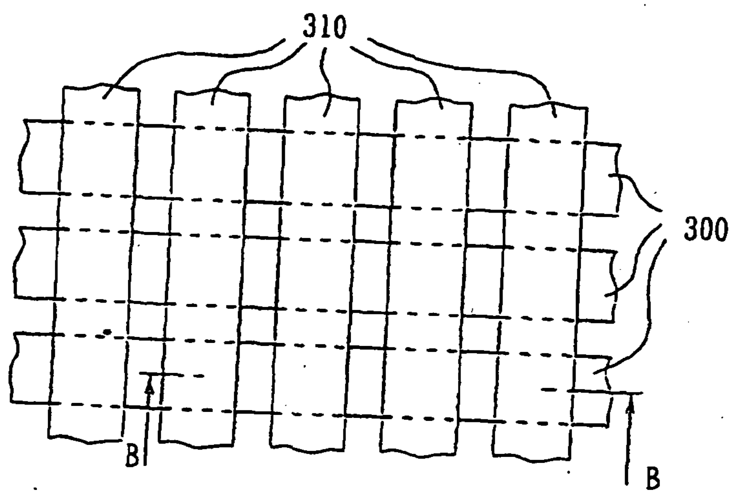

114B
140A
132
133
240
238
230
220
121
(a)
141
236
143
140b
140A
(b)
140B
140A
140
(c)
154
(d)
140B 140A 141 143
140

[FIG. 6]

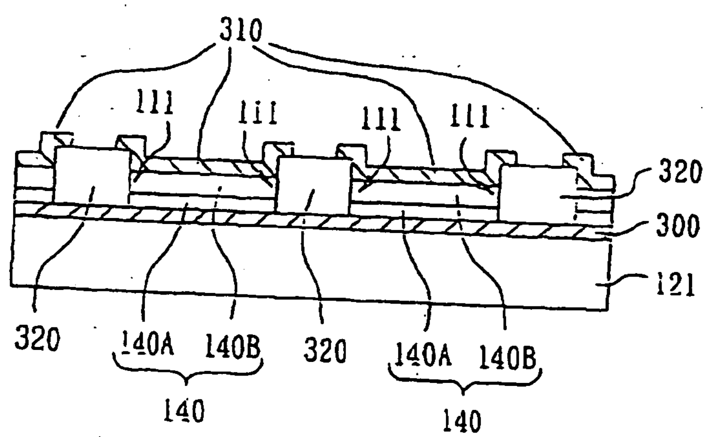


[FIG. 7]

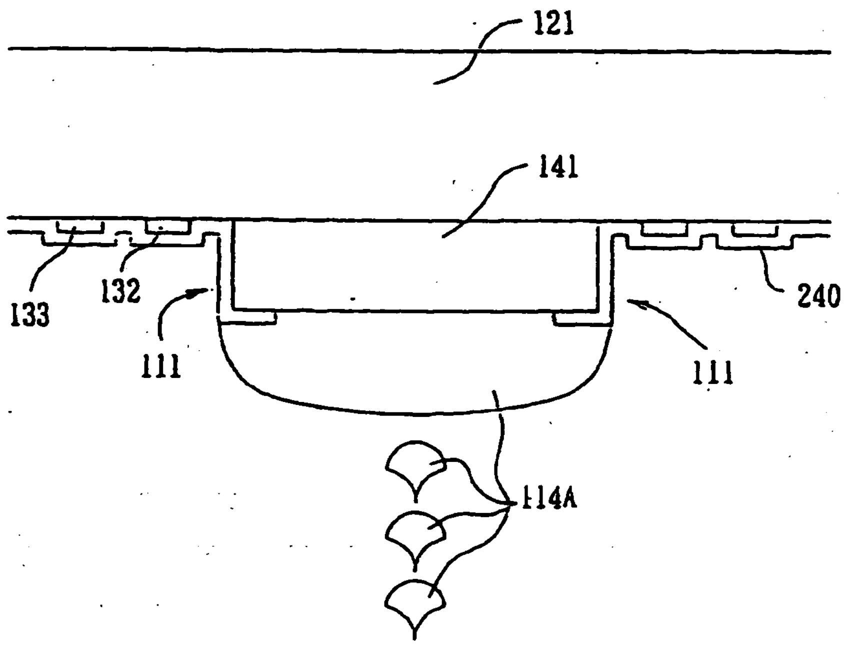
(a)


310
300
B
B

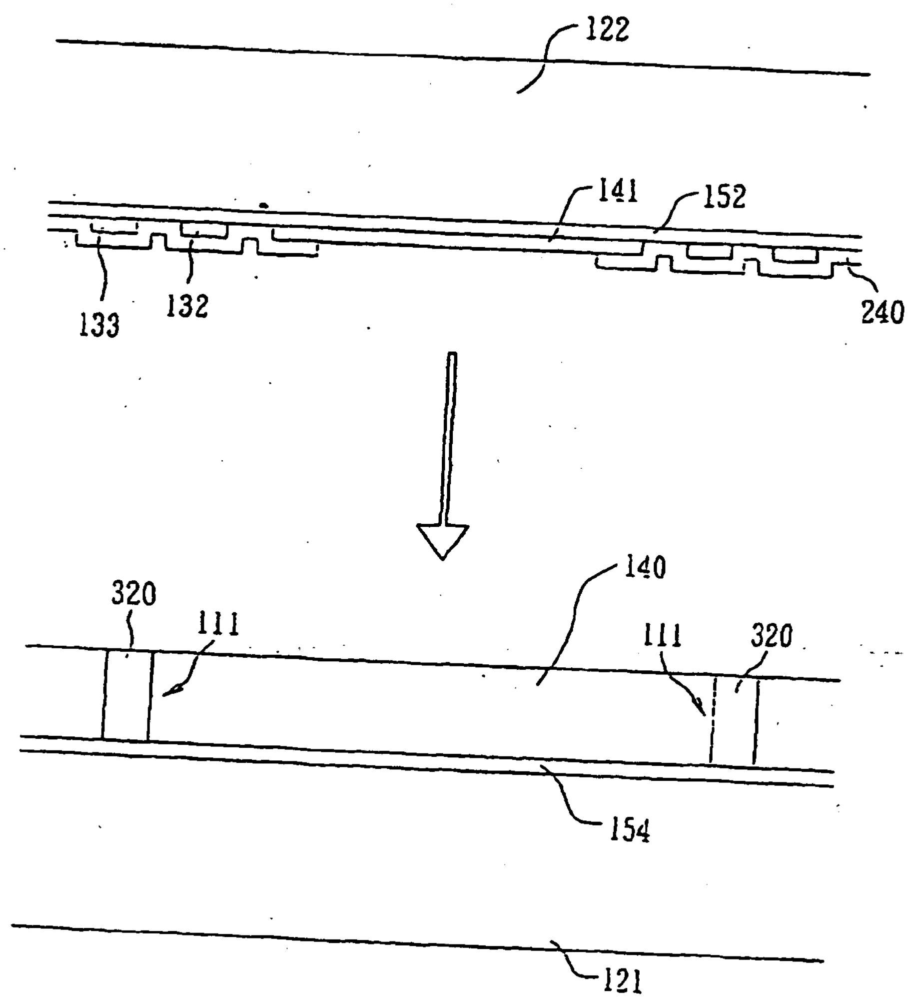
(b)


310
111
111
111
111
320
300
121
320
140A
140B
320
140A
140B
140
140

[FIG. 8]



[FIG. 9]



[FIG. 10]